

## LHC and Grid Computing

Slides: [http://cern.ch/Hans.Hoffmann/LHC&Grid\\_US\\_Rev.ppt](http://cern.ch/Hans.Hoffmann/LHC&Grid_US_Rev.ppt)

- **The Challenge: partially discussed, more slides in printout**
- **Grids**
- **"Hoffmann" Review**
  - **Mandate, members: not discussed, slides in printout**
  - **Results**
- **Further procedures at CERN**

## LEP Case (very small data volumes!)

Slides at: <http://cern.ch/davidw/public/LEPfest.ppt>

**1983 LEPC: 2 CERN units required per experiment; ALEPH: 12 units**

**1983: Green Book - Computing at CERN in the LEP Era:**

- **"Users": <50 per experiment at CERN; ~100 per experiment outside CERN (Europe, NA, RoW added)**
- **Compute power, data storage, disk, networking, . . . , other**
- **Simulation**

**1984: CERN computing cost ~ 50 MCHF over the following 5 years**

**1988: 13.5 CERN units/expt. estimated and a similar amount outside**

**2000: ~2000 CERN units (200 SI-95), ~2.5 Tbytes of disk LEP expt.**

**Achievements: PAW, Geant 3, WWW, "coherence" across users distributed over many institutes and countries: "massively scaling" software**

**Mainframes ⇒ workstations ⇒ PCs/commodity/massive networking**

**Important technology changes**



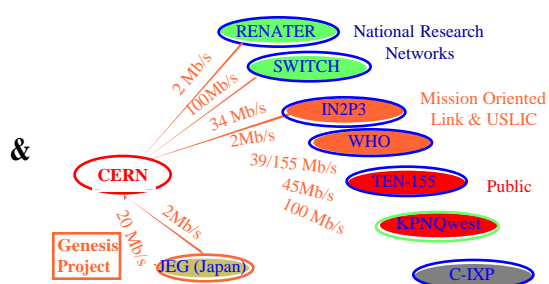
**IBM 370/168 - the "CERN Unit"**  
(10 CER N Units: 1 SI95)



**Computer Room in 1985**



**PC farms in 2000**



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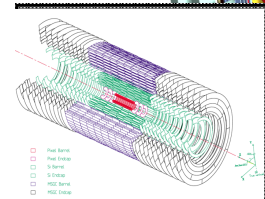
3

## The Compact Muon Solenoid (CMS)

### SUPERCONDUCTING COIL

Total weight : 12,500 t  
Overall diameter : 15 m  
Overall length : 21.6 m  
Magnetic field : 4 Tesla

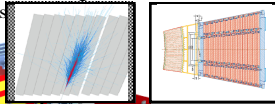
### TRACKERS



Silicon Microstrips (230 sqm)  
Pixels (80M channels)

### CALORIMETERS

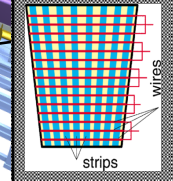
ECAL Scintillating PbWO<sub>4</sub> Crystals  
HCAL Plastic scintillator copper sandwich



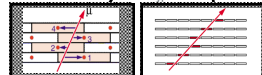
### IRON YOKE

### MUON

### ENDCAPS



### MUON BARREL



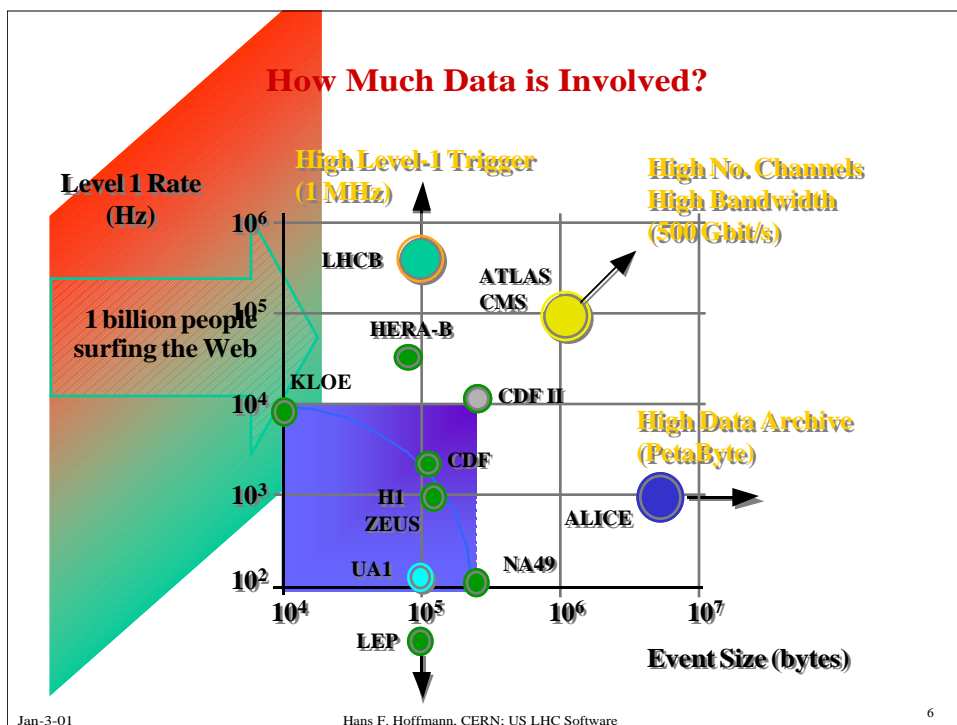
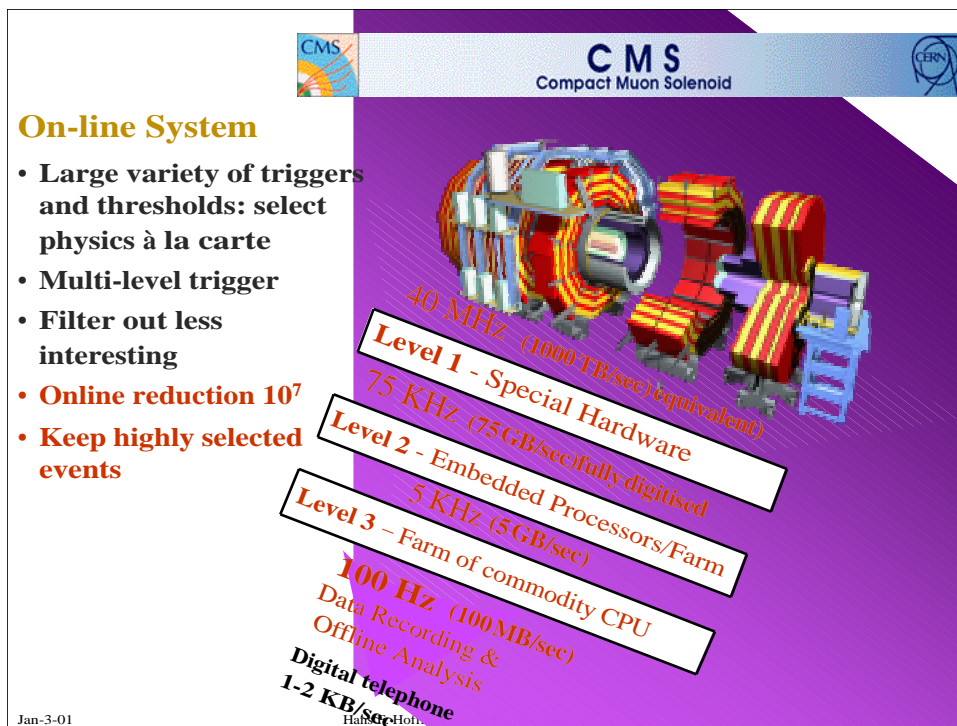
Drift Tube Chambers DT  
Resistive Plate Chambers RPC

Cathode Strip Chambers CSC  
Resistive Plate Chambers RPC

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## CERN's "Network" in the World

267 institutes in Europe, 4603 users  
208 institutes elsewhere, 1632 users  
some points = several institutes



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7

## HPC or rather HTC

### High Throughput Computing

- mass of "modest" problems
- throughput rather than performance
- resilience rather than ultimate reliability

Can exploit **inexpensive mass market** components

But we need to marry these with

**inexpensive, highly scalable management tools**

Much in common with data mining, Internet Service Providers, e-commerce, data marketers ... ..

Much less in common with traditional supercomputing (HPC)

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# Today's Analysis Farms

## Computing & Storage Fabric

built up from commodity components

- Simple PCs
- Inexpensive network-attached disk
- Standard network interface  
(whatever Ethernet happens to be in 2006)

with a minimum of high(er)-end components

- LAN backbone
- WAN connection

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9

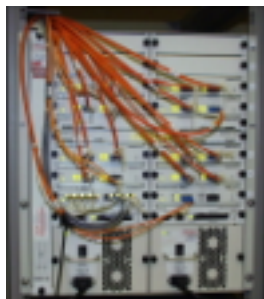
## Limited role of high end equipment

### Computing & Storage Fabric

built up from commodity components

- Simple PCs
- Inexpensive network-attached disk
- Standard network interface  
(whatever Ethernet happens to be in 2006)

with a minimum of high(er)-end components



LAN backbone



WAN connection

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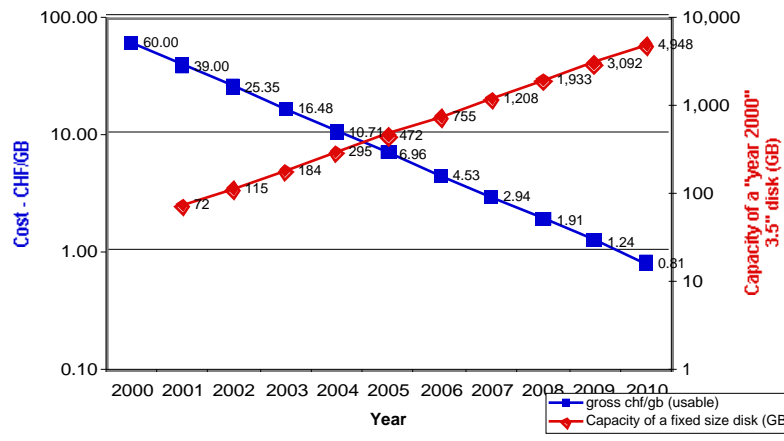
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## TechnologyWatch, Context and Challenge

### Projected evolution of Cost of Disk Storage, Storage Density (mirrored IDE disk, usable capacity)

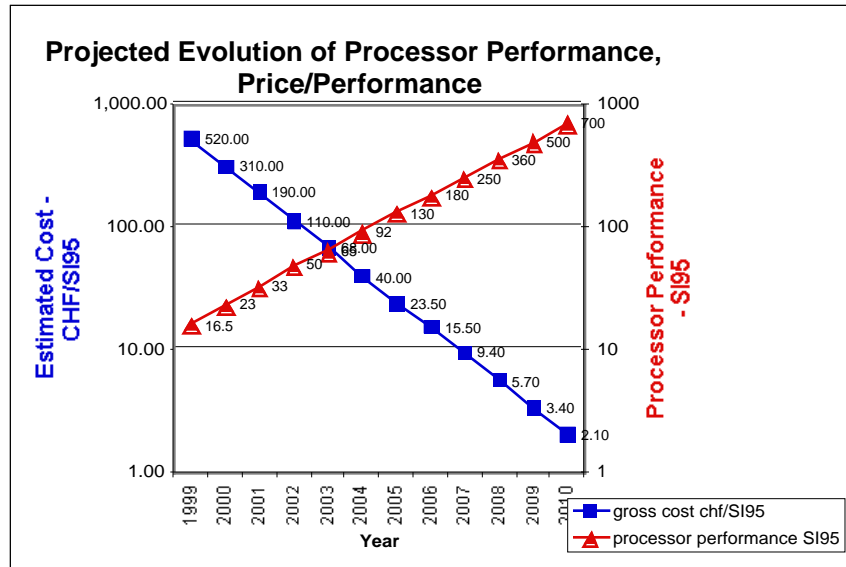


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12

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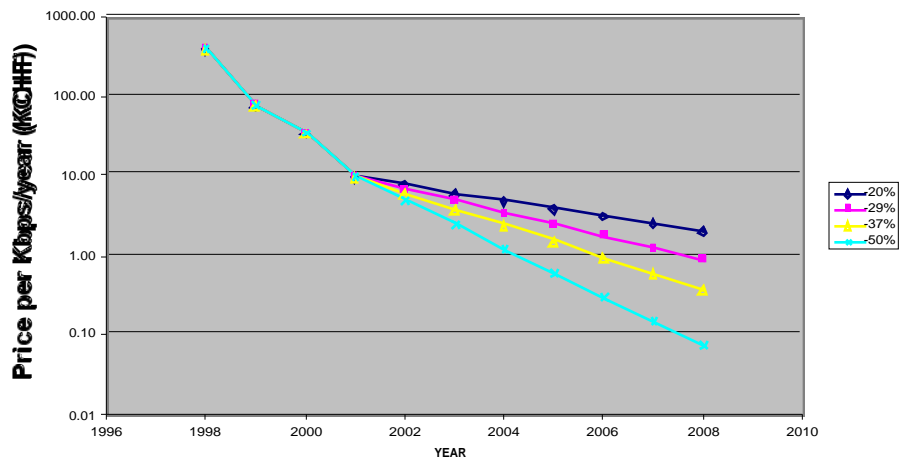
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13

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### Evolution of Transatlantic prices



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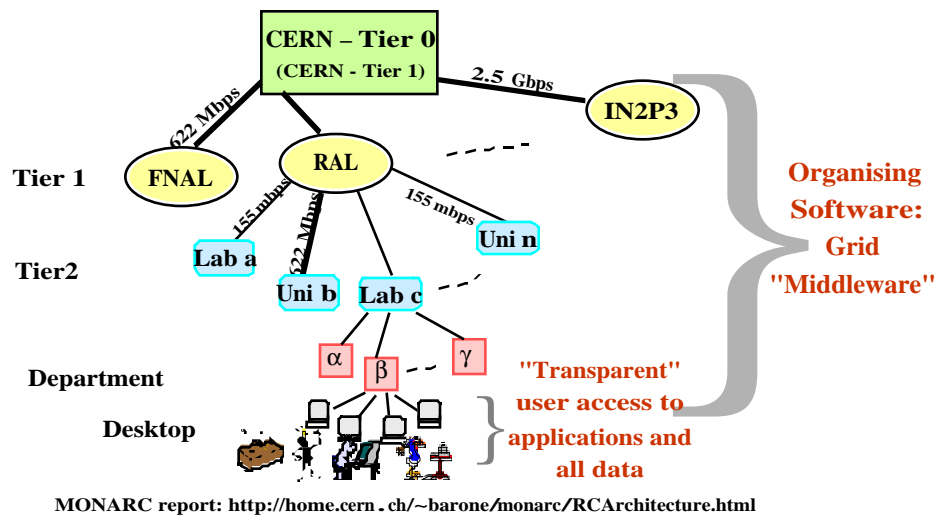
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## LHC Computing - a Multi-Tier Model

### Monarc study: complete simulation of the model



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## EU-DataGrid and LHC (<http://grid.web.cern.ch/grid/>)

- High Throughput, Data-intensive Computing Fabric as a **Computational Data Grid** in Europe, to stimulate development of the missing software
- Construct a common testbed for pilot applications from several sciences (e-Science), industries
- Prove resulting scalability, usability and quality in production environment --  
demo of an LHC distributed facility
- Leverage current R&D on **Computational Grids** adding a **data intensive** perspective

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## Grid initiatives

**DataGRID; European HEP Grids, (INFN Grid, UK Grid, France, NL..)**

**GriPhyN; PPDG**

**Japan; Asia-Pacific Grid**

**Coordination needed between GriPhyN and DataGRID, PPDG, others in terms of Management, Architecture, Middleware, Deployment**

**Good News:**

- Globus underlies all of the projects
- Active participation of Globus leadership in all of the HEP projects
- Merging of Grid Forum and eGrid to form **Global Grid Forum** – North America – Europe – Asia – Pacific (Global Grid Forum 1 (GGF1), will be held in Amsterdam, Netherlands, March 4-7, 2001)

**Good support for GLOBUS in Europe must be organised – and funded**

**Essential to get the DataGRID Phase 0 testbed off the ground**

**Scope for collaboration and cooperation**

**or duplication and incompatibility**

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## LHC Computing Review

**Announced in autumn 1999**

**First Steering Committee meeting 12/1999**

**By end of 'spring' (June 2000) the review team should have helped to formulate and then comment**

- substantiated software projects
  - world-wide analysis schemes and
  - the preliminary resource loaded work-plans,
- with milestones and objectives, supplying a coherent picture between experiments and CERN IT division**

**However:**

**end 1999: distributed computing model, Monarc, --> Data Grids  
establish common views amongst 4 LHC Experiments and more solid  
estimates of the needs**

**More time required than envisaged, finish by end of this year**

**Status report now with preliminary results**

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18

## **Mandate (Introduction)**

**At about mid-term between the publication of the technical proposals of the experiments and the start-up of LHC, and well before the submission of the computing TDRs of the experiments, it is an appropriate moment to review the computing plans of the LHC experiments and the corresponding preparations of IT Division with the following aims:**

## **Mandate**

- ❖ Update the assessment of individual, experiment-specific, regional and CERN facilities, and their relative roles required to perform the computing of the LHC experiments. Update the estimates of the corresponding resources required, taking into account the evolution of the underlying technologies. Identify the software packages to operate in the various places. Identify services to be provided centrally. Identify activities which have to be done at CERN.**
- ❖ Assess the analysis software projects, their organisational structures and interfaces between parts, the corresponding role of CERN and possible common efforts.**
- ❖ Review and comment about the overall and individual computing project management structures and review the resources required**

## **Mandate (Comments)**

**The results of the review will be the basis for CERN, the collaborating institutes and their funding agencies to formulate Computing Memoranda of Understanding. These will describe the commitments of institutes inside the collaborations towards their computing goals and the commitments of CERN to provide software, computing infrastructure and central facilities for the LHC era. The MoUs should be put in place in 2001 -2002.**

**The review team should recommend actions and, in particular, common actions between experiments and IT Division that will help to achieve these goals within the existing resources.**

**The review reports to the Research Board and the Director General.  
Interim status reports will be given to FOCUS, LHCC and other appropriate bodies.**

## **Organisation**

**Steering Committee, under which operate three technical panels:**

- Worldwide Analysis/Computing Model panel**
- Software Project panel**
- Management and Resources panel**

**The Steering Committee meets monthly and the panels organise their own schedule of meetings**

**Communication by email, private Web Site and public Web Site:**

- <http://cern.ch/lhc-computing-review-public>**

## Membership (1)



Chair



Secretary

### Steering Committee

**Members:** **S. Bethke** Chair  
**H.F. Hoffmann** CERN Director resp. for Sc. Comp.  
**D. Jacobs** Secretary  
**M. Calvetti** Chair of the Mgmt and Resources Panel  
**M. Kasemann** Chair of the Software Project Panel  
**D. Linglin** Chair of the Computing Model Panel

#### Representative Alternate

**In Attendance:** IT Division **M. Delfino** **L. Robertson**  
ALICE **F. Carminati** **K. Safarik**  
ATLAS **N. McCubbin** **G. Poulard**  
CMS **M. Pimia** **H. Newman**  
LHCb **J. Harvey** **M. Cattaneo**

**Observers:** **R. Cashmore** CERN Director for collider programmes  
**J. Engelen** LHCC chairman

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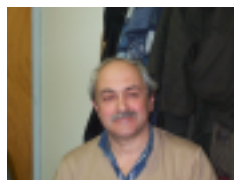
23

## Membership (2)

### Worldwide Analysis/Computing Model panel



Chair



Secretary

**D. Linglin** Chair  
**F. Gagliardi** Secretary (--> lost to EU-Data Grid)

**Expt. Reps:** **Representative** **Alternate**  
ALICE **A. Masoni** **A. Sandoval**  
ATLAS **A. Putzer** **L. Perini**  
CMS **H. Newman** **W. Jank**  
LHCb **F. Harris** **M. Schmelling**

**Experts:** **Y. Morita**, **L. Perini** **C. Michau**

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24

## Membership (3)

### Software Project panel

Picture to be added;  
Matthias please send

Chair



Secretary

**M. Kasemann** Chair

**A. Pfeiffer** Secretary and CERN-IT representative

Expt. Reps:	Representative	Alternate
ALICE	R. Brun	A. Morsch
ATLAS	D. Barberis	M. Bosman
CMS	L. Taylor	T. Todorov
LHCb	P. Mato	O. Callot

Experts: **V. White**, etc.

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## Membership (4)

### Management and Resources panel



Chair



Secretary

**M. Calvetti** Chair

**M. Lamanna** Secretary

Expt. Reps:	Representative	Alternate
ALICE	P. Vande Vyvre	K. Safarik
ATLAS	J. Huth	H. Meinhard
CMS	P. Capiluppi	I. Willers
LHCb	J. Harvey	J.P. Dufey

Experts: **L. Robertson** **T. Wenaus**, etc.

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26

## **Review Meetings and Status**

**Software Panel: wide consensus on software matters and final report**

**World-Wide Computing Panel; the distributed computing model is confirmed and a preliminary report has been received containing preliminary requirements**

**Resources Panel: start later, wait for information to consolidate, meetings together with the world-wide computing panel, turning requirements into resource estimates, very preliminary report received, feedback from RRB will be important**

**Steering Committee: 15 meetings until 16-11-00 included, aiming at a final report by the end of the year**

**More information on the review:**

**(<http://lhc-computing-review-public.web.cern.ch/lhc-computing-review-public/>)**

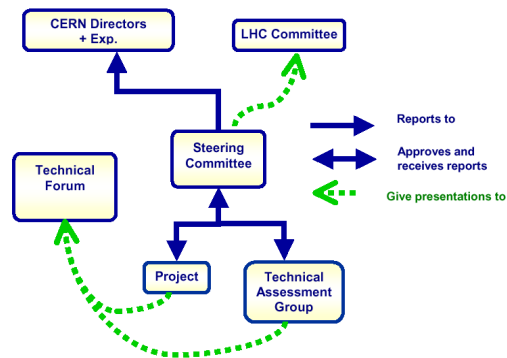
## **Preliminary outcome today**

- **Intense and collaborative discussions between experiments amongst themselves and with IT Division**
- **Emerging views on common efforts in software and testbeds**
- **Computing efforts outside CERN discussed with funding agencies and some encouraging activities noted  
(concrete preparations for regional centres in a number of countries)**
- **First ideas about Management Structure for the coming years, embedded into LHCC, Research Board, RRBs, bringing together all parties involved  
(Software and Computing Steering Committee "CS<sup>2</sup>")**

- **Manpower shortfall, maturity of planning and resource estimates**
- **Simulation packages development and support**
- **Software and system architectures**
- **Common projects and experiment/IT division interactions**
- **Data management**
- **Analysis tools support and future evolution**
- **Quality assurance of physics reconstruction/filter/trigger code**

29

- **Establish LHC Software and Computing Steering Group**  
(preliminary diagram; detailed description in final report)



- **Establish data management technical assessment group**
- **Validate and present manpower needs and current availability**
- **Initiate technical assessment groups in a number of areas**

30



## **"World-wide Analysis and Computing Model" Panel Report**

30 September, 2000; Draft 2.1

- The Panel recommends the multi-tier hierarchical model as one key element of the LHC computing model **with the majority of the resources not based at CERN.**
- About equal share between Tier 0 at CERN, Tier 1's and lower level Tiers down to the desktops:  
 **$\text{Tier0}/\Sigma (\text{Tier 1})/\Sigma (\text{all Tier 2, etc}) = 1/1/1$**
- The Panel recommends that all experiments perform **"Data Challenges"** of increasing size and complexity until LHC start-up (interest has been expressed to use the emerging structure for real data of real experiments)
- Creation of a Software and Computing Steering Committee ( SC<sup>2</sup> )

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31

## **Key Parameters**

- Typical numbers for a multipurpose experiment:
    - **10<sup>9</sup> events/s** at nominal luminosity of 10<sup>34</sup>/cm<sup>2</sup>s in bursts at 40MHz
    - **100 events/s** to data storage (270 events/sec)
    - **1 M Byte/ event** (2 M Byte/event)
    - **10<sup>7</sup> s** running time per year (0.5 \* 10<sup>7</sup> s )
- data rate ∝ stable beam time**
- **2 Peta Byte/yr "raw" data**
  - **1 Peta Byte/yr simulated data**

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32

### **Key parameters, continued**

- **All LHC experiments, Tier 0 & 1 at CERN :**
  - **10 Peta Bytes/yr data storage; disk: 2 P Byte**
  - **2 M SI 95 (PC today ~ 20SI95)**
- **Multi-experiment Tier 1:**
  - **~ 5 Tier 1/experiment**
  - **3 Peta Byte/yr data storage; disk: 0.5 P Byte**
  - **0.9 M SI 95**
- **$\Sigma$  (Tier-2s and below attached to Tier 1) ~ Tier 1 without data storage  
(order of magnitude, very preliminary)**
- **Networking Tier 0 --> Tier 1:  $\geq 622$  Mbps (4 Gbps)  
(black fibre: 1 Tbps)**

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33

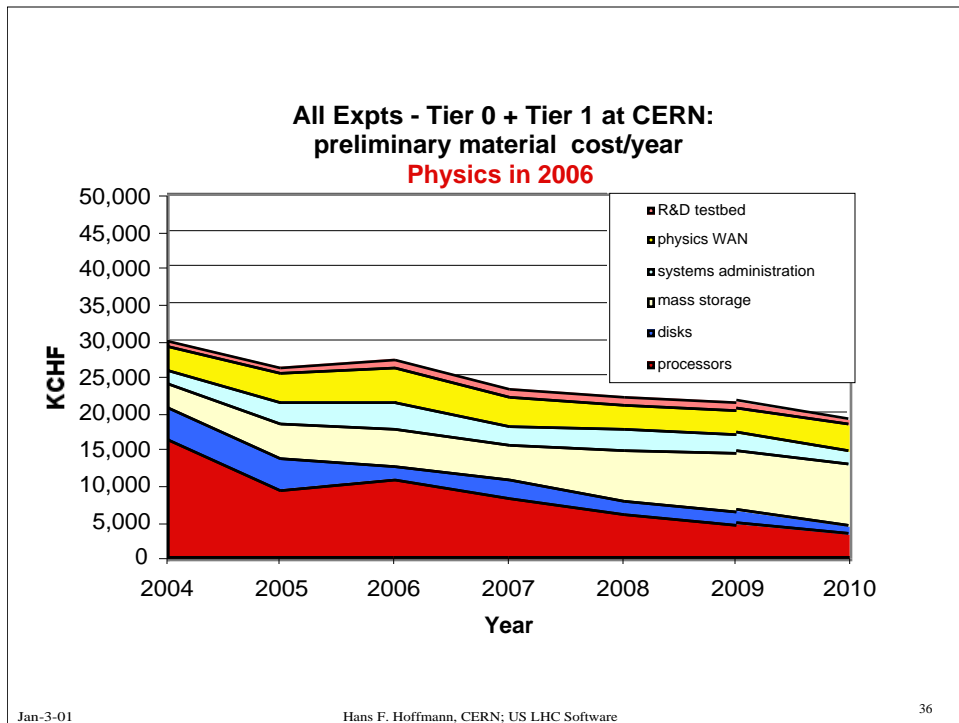
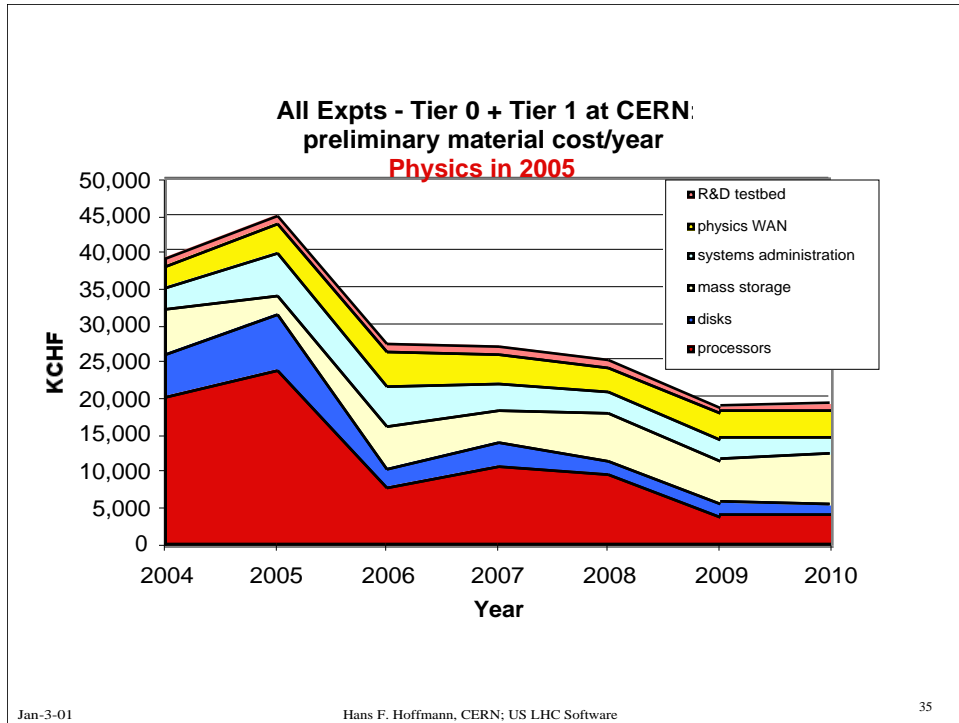
### **Preliminary findings of the Management and Resources Panel of the LHC Computing Review, v. 1.1; 15-9-00**

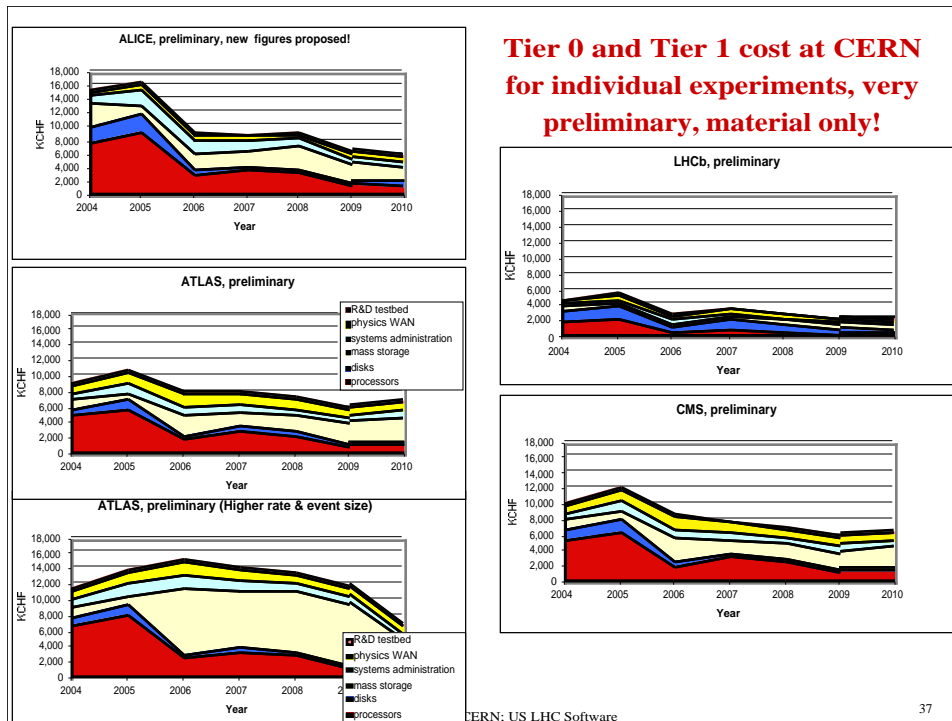
- **Estimates collected of the computing resources required by the 4 LHC experiments**
- **Estimates will need consolidation for the final report and then further refinements in the coming years from experience gained with tests**
- **Many more detailed suggestions, not necessarily agreed by expts:**

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34





### Comments on Cost Figures presented

- **Material cost estimates based on commodity components (except tape and networking equipment) and technology watch:**  
**Very preliminary and only indicative!**
- **The start-up scenario of LHC machine and experiments has a very important influence on cost: needs discussion and evaluation of LHCC to evaluate physics merits and initial understanding of detector systematics**
- **Network bandwidths: Fastly evolving field and may have to be re-evaluated in the light of BABAR and BELLE experiences**
- **Further cost developments after first years of running will have to be re-evaluated because of the rapid technology changes**
- **Material cost of Tier 1 and below can be scaled to some degree from the presented figures.**
- **Manpower and operation cost for all Tiers (0->Desktop) are not included and need more work at CERN and in the countries concerned (every country will be different!)**

## Manpower Evaluations

- Estimates of professional manpower needs have been received from the 4 experiments to build and operate their software:  
**missing FTEs/experiment range from 8-25**
- Software is subdivided into "core software" written by professionals and physics analysis software, written by physicists
- Core software teams are not necessarily located in one place,
- More in detail:
  - the number of FTE software engineers is compatible with the experience of existing experiments (Babar, CDF)
  - adequate support of the Core-Software team is necessary. The resources for the **core-software team must be found within the collaborations** which should present plans describing how to provide the necessary support
  - co-ordination of the 4 core-software teams with the CERN IT Division is necessary; IT Division does not have sufficient manpower to satisfy all requests
  - there is enough manpower inside each collaboration to build the physics-specific software

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39

## Further Procedure at CERN, before the end of the year

-Technical paper ("technical proposal") on CERN - IT Division plans for LHC Computing, including schedules, cost and additional manpower requirements (fabric, software support, coordination); built-up towards the final Tier0, Tier1; LHC schedule and initial operation plans

-A "white", draft paper named "LHC and Grid Computing" to CERN Scientific Policy Com. and Com. of Council (December 2000 Meetings)

-First description of a special programme, "LHC and Grid Computing" open to MS and NMS, with requests for resources at CERN and in the collaborating countries

-Interest of such a programme for other sciences

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40